# UCSB HYPERLOOP

University of California, Santa Barbara

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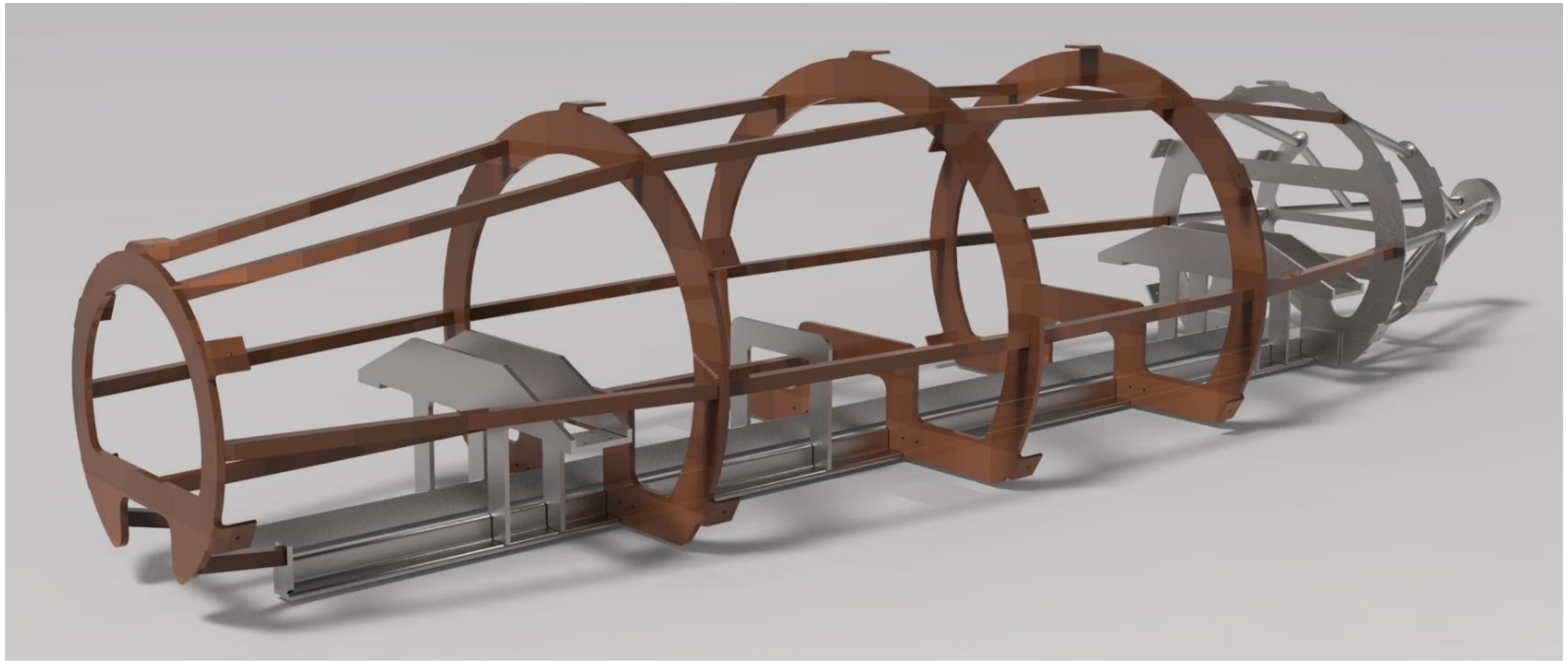
# INTRODUCTION

- Follow along at **ucsbhyperloop.com/dw**
- 21 senior engineering undergraduates working to build and test a pod at Competition Weekend
- Emphasizing cost-effectiveness, scalability, and feasibility
- Estimated cost to complete design: $40,000
  - Funding/resources already raised:
    - $5,000 from Ingersoll Rand
    - $5,000 from Raytheon
    - $5,000 from private donors
    - Electronics donated by NXP Semiconductors
  - **~$25,000 to be raised**

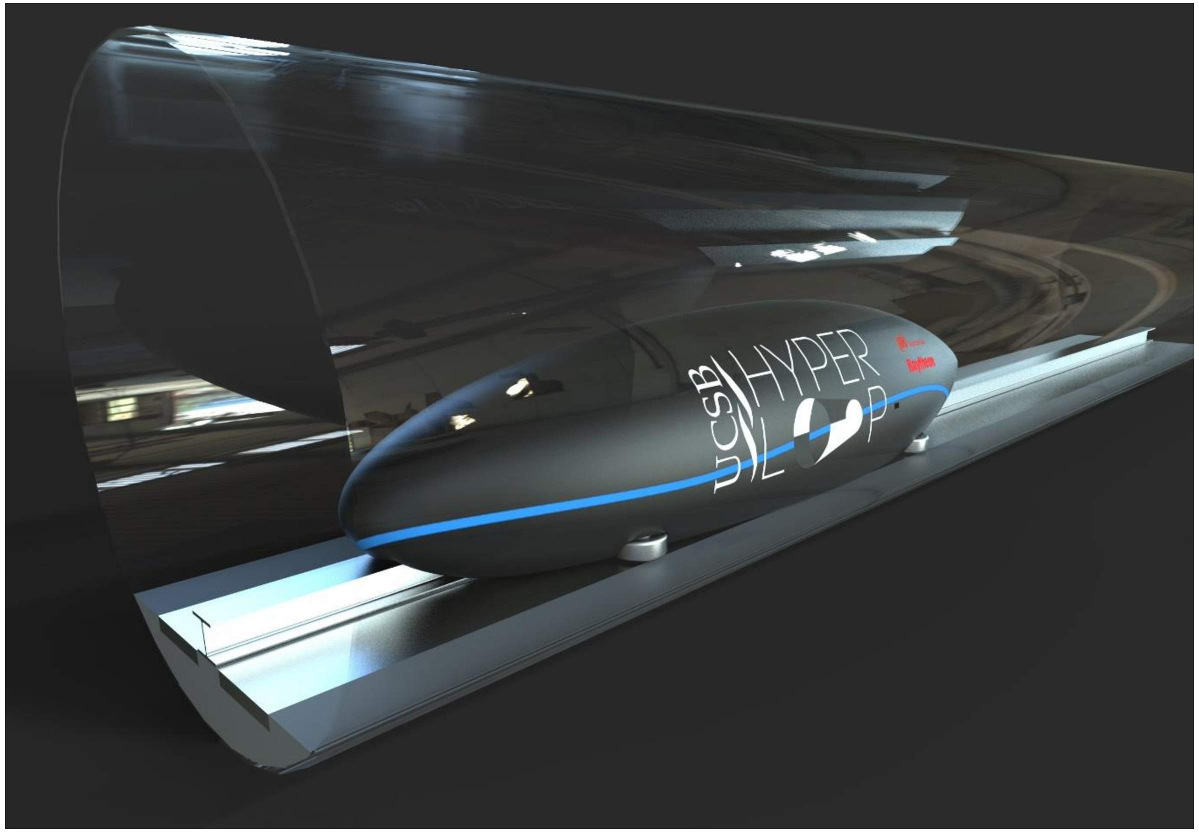
# FRAME

- 13’7” (length) x 3’4” (width) x 2’7” (height)
- Divided into front, base, and rear frame
  - Lightweight, wooden front frame reinforces shell
  - Aluminum base frame supports all major subsystems
  - Steel tube rear frame interfaces with SpaceX pusher



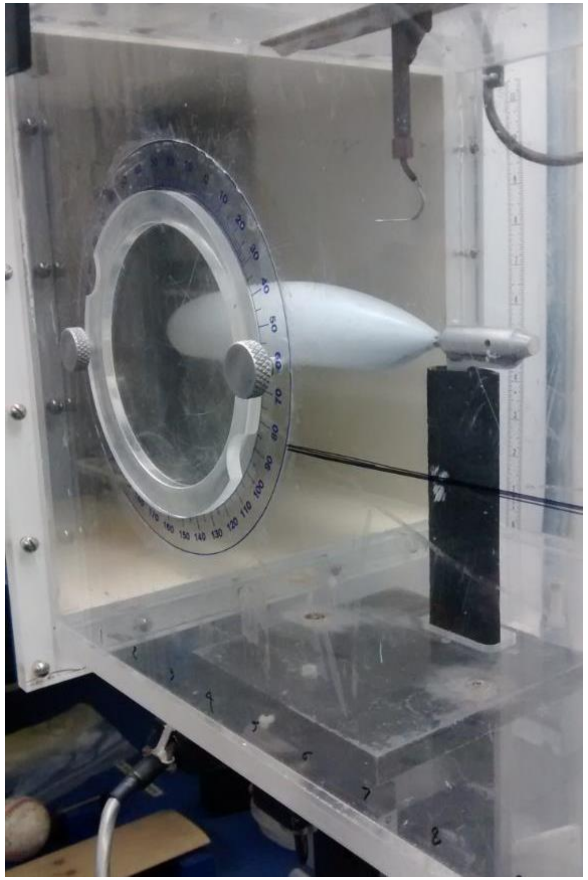
# SHELL

- Tapered bullet shape
- E-Glass reinforced polyester
  - Uniformly strong in all directions



# WIND TUNNEL TESTING

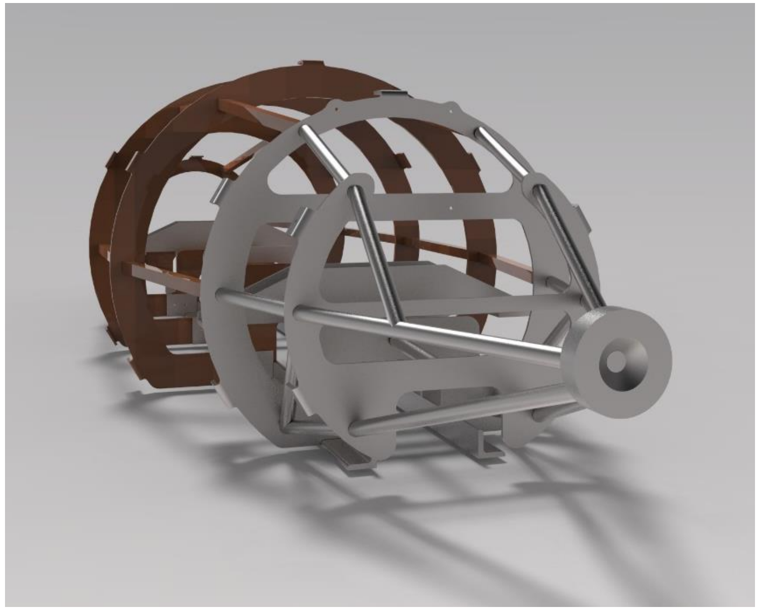
- 3-D printed ABS plastic pod model
- Reynolds number in evacuated tube is $8.5\times10^3$
- Estimated drag coefficient = 1.5
  - Drag force at 0.02 psi = 1.5 lbs

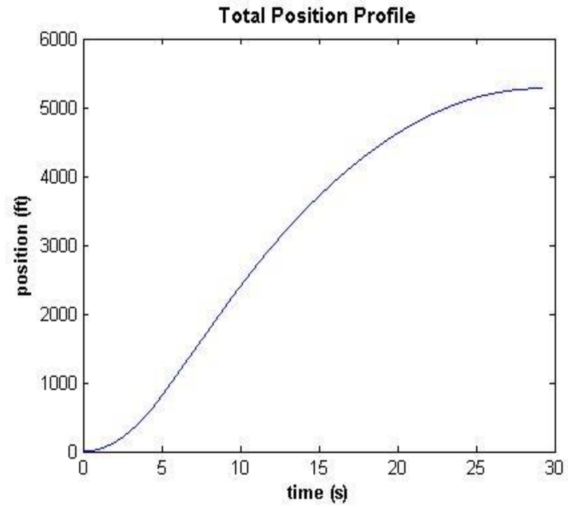


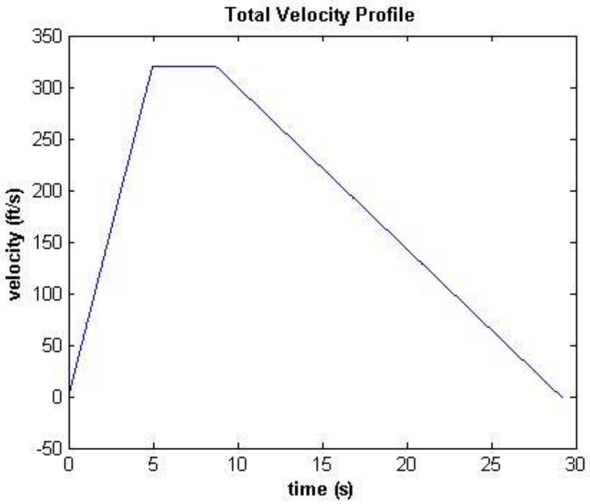
Pod model mounted in wind tunnel

# TRAJECTORY

- Top speed of 218 mph (320 fps)
- Total run time of 29.16 s
  - Acceleration – 4.98 s
  - Coasting – 3.75 s
  - Braking – 20.43 s

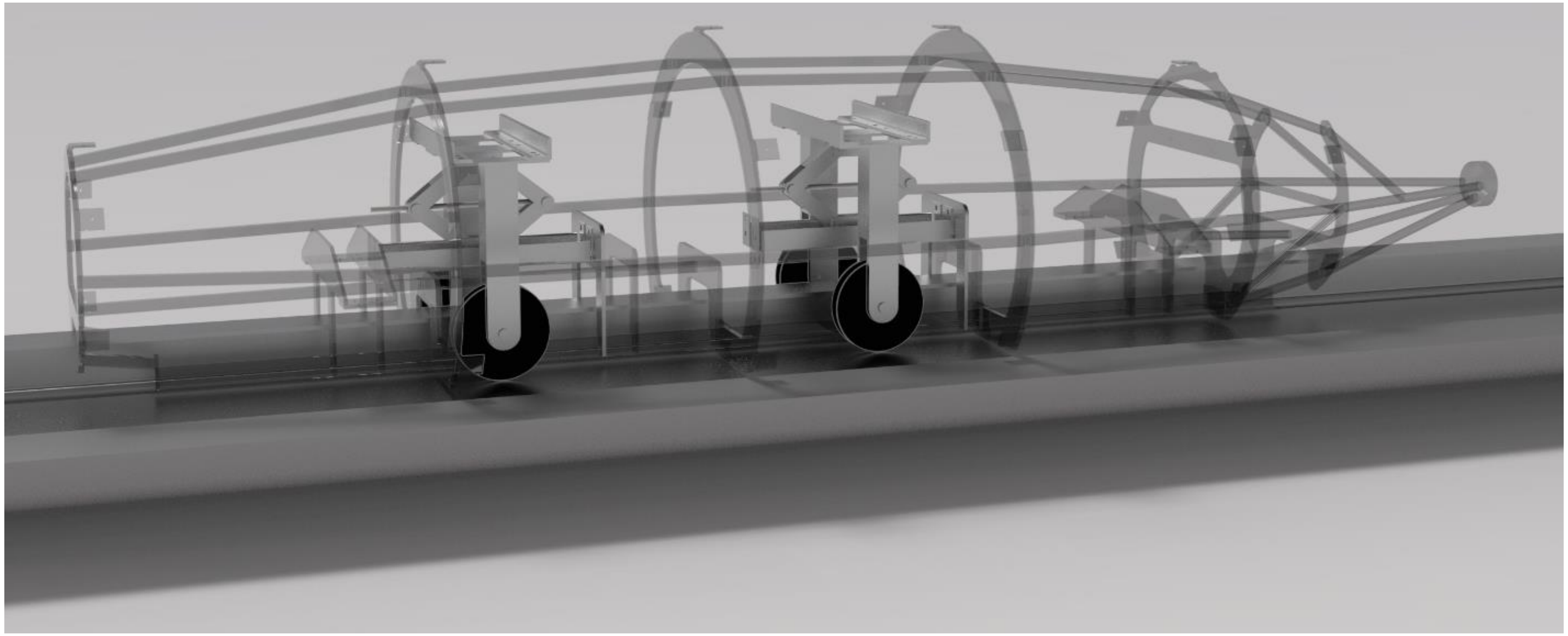




# SERVICE WHEELS

- Powered service wheels for transport and potential pod recovery
- Wheels extend 1/8” below hover engines
- Motorized rear-left support wheel



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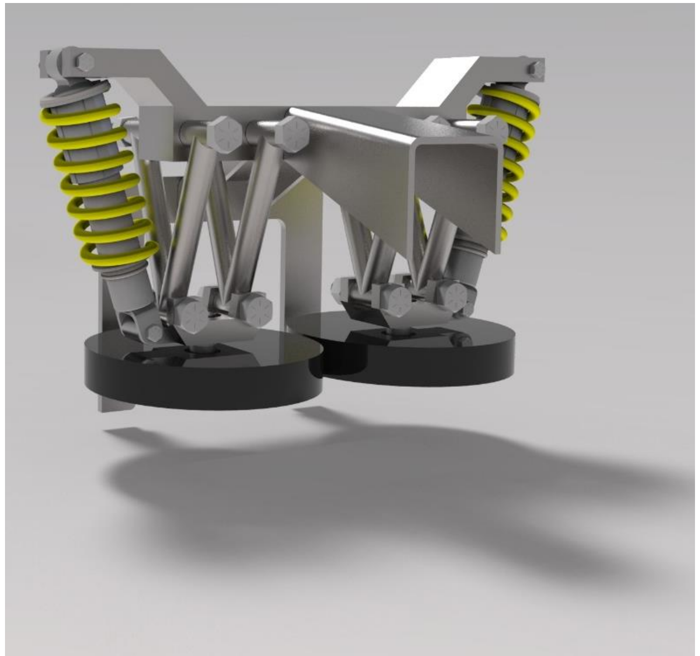
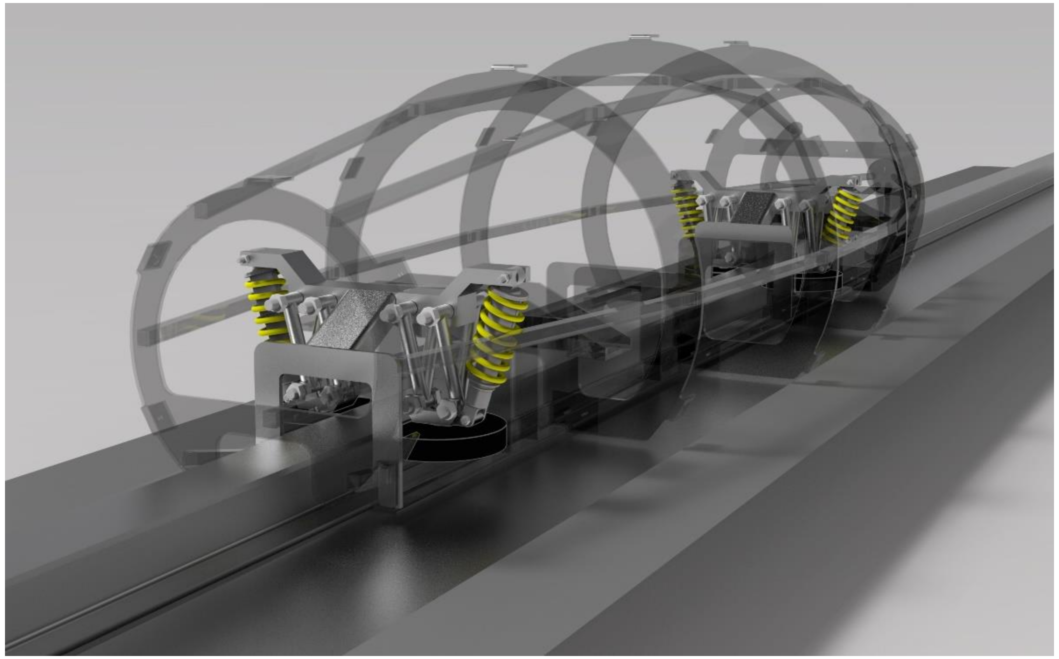
# I-BEAM STABILIZATION

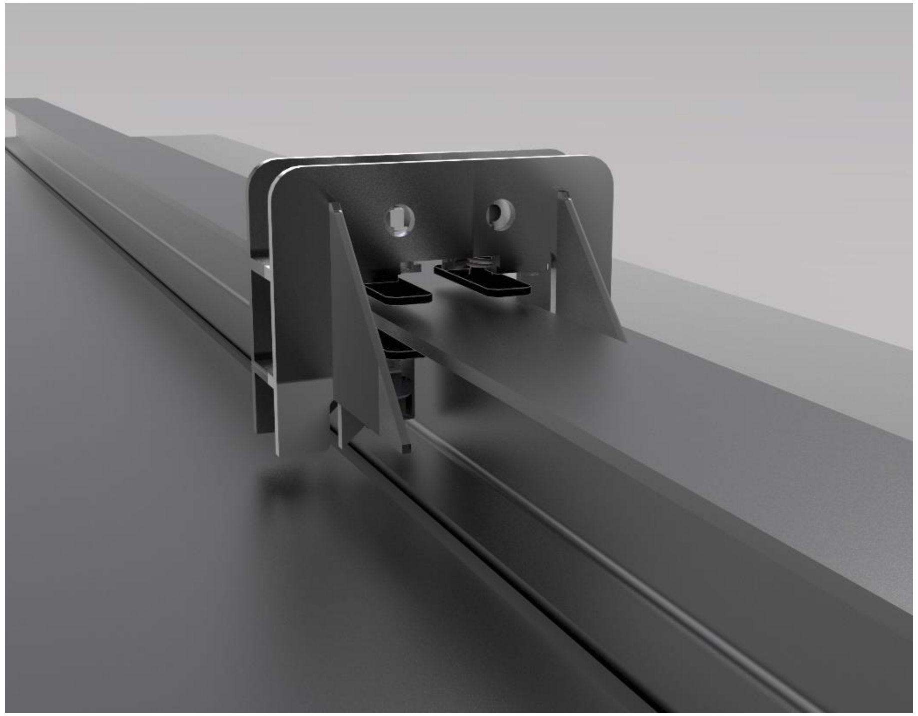
- Benchmarked from roller coaster design and car/motorcycle suspension systems
- Spring-damper resists movement from the parallel linkage
  - Handles lateral forces

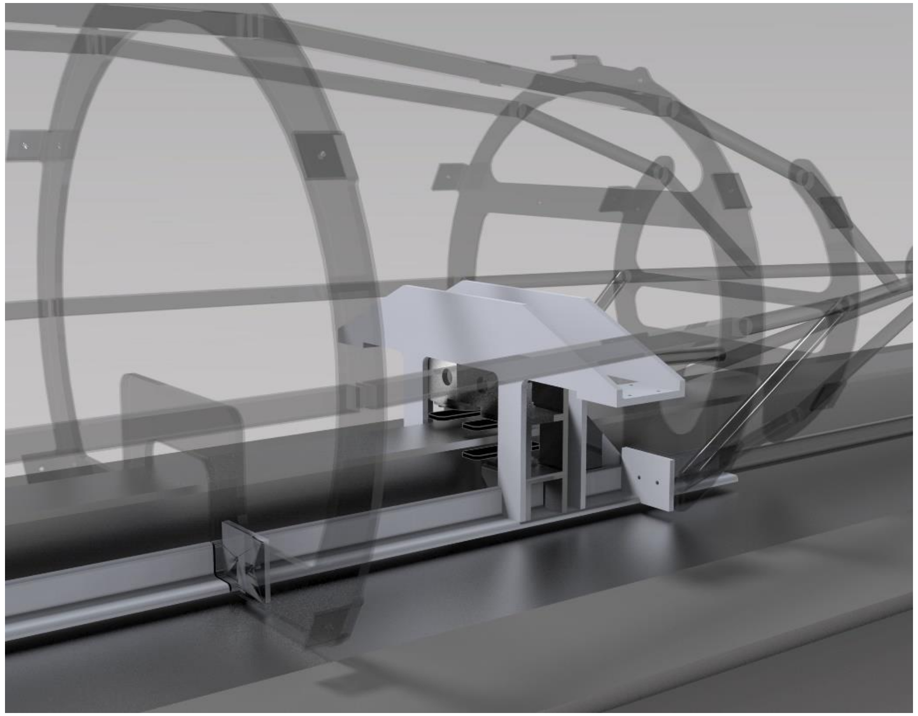




# BRAKING

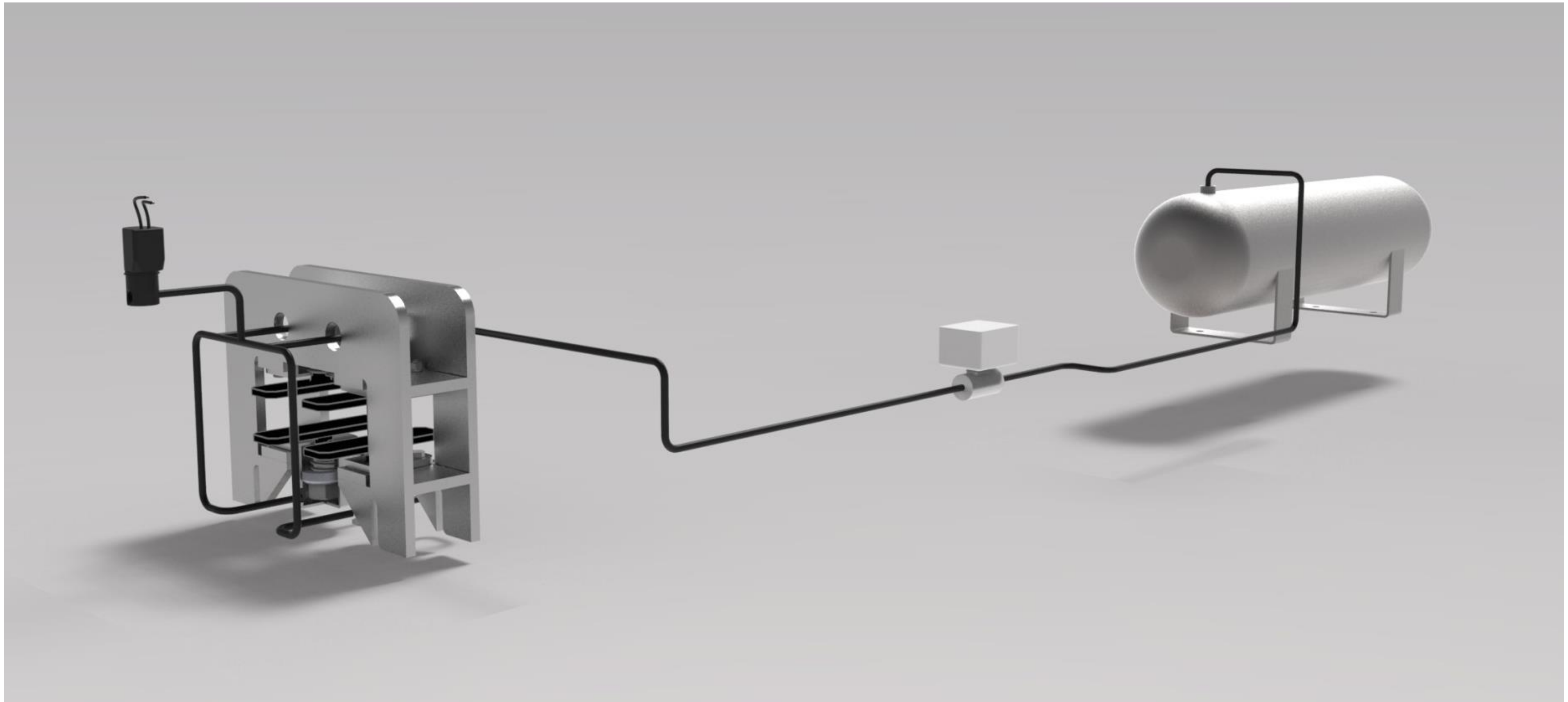
- Pneumatic braking assembly with four actuated brake pads
  - Brake pads clamp onto the I-beam
  - Located at rear of pod





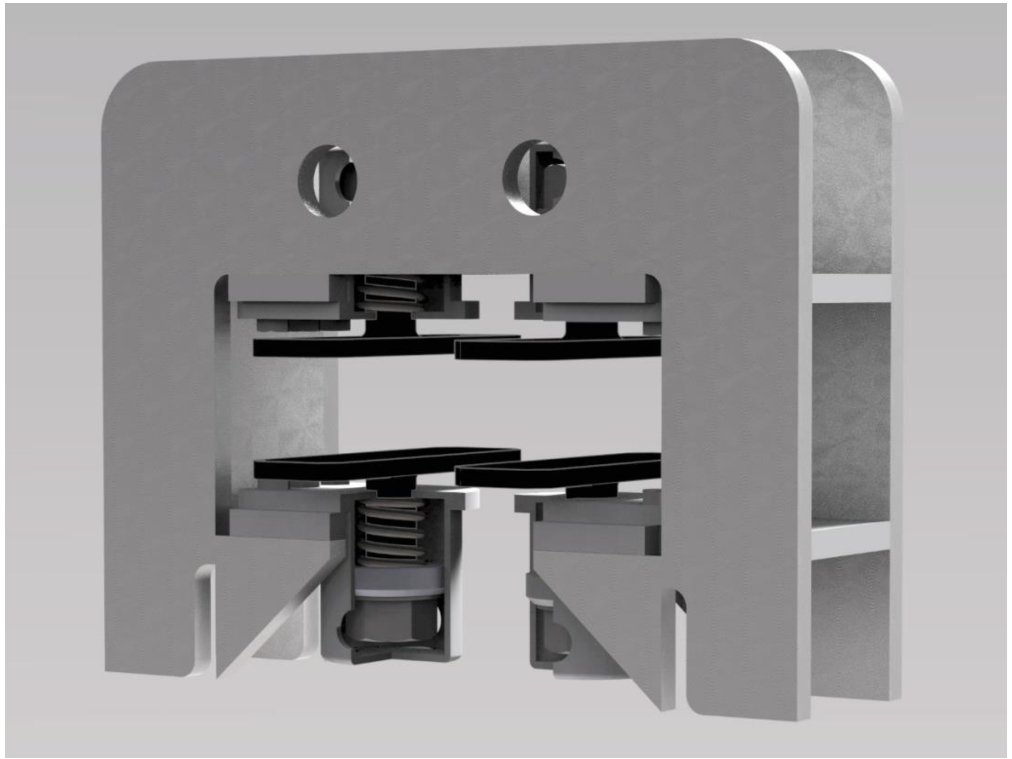
# BRAKING

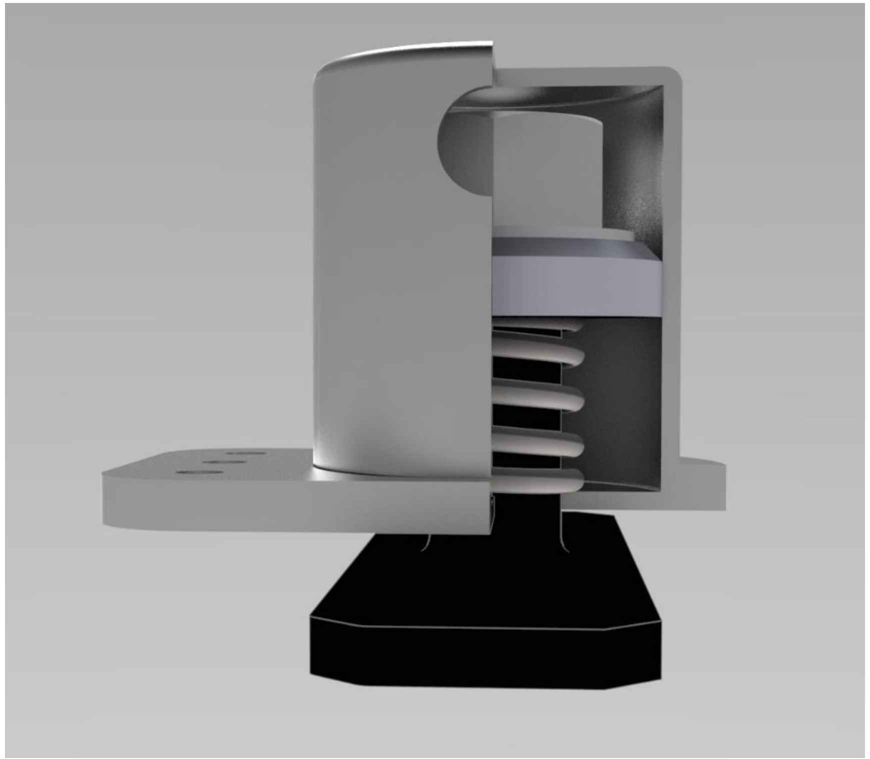
- Pressurized air tank provides pneumatic brake force



# BRAKING

- Braking automatically activated by solenoid valves if power fails
- Ball valve manually disengages the brakes





# POD WEIGHT

| Subsystem | Weight |
|---|---|
| Frame | 66 lbs |
| Shell | 83 lbs |
| Service Propulsion Wheels | 96 lbs |
| I-Beam Stabilization | 60 lbs |
| Braking | 27 lbs |
| Magnetic Levitation Engines | 60 lbs |
| Battery and Electronics | 63 lbs |
| **Total Weight** | **455 lbs** |

# MAGNETIC LEVITATION

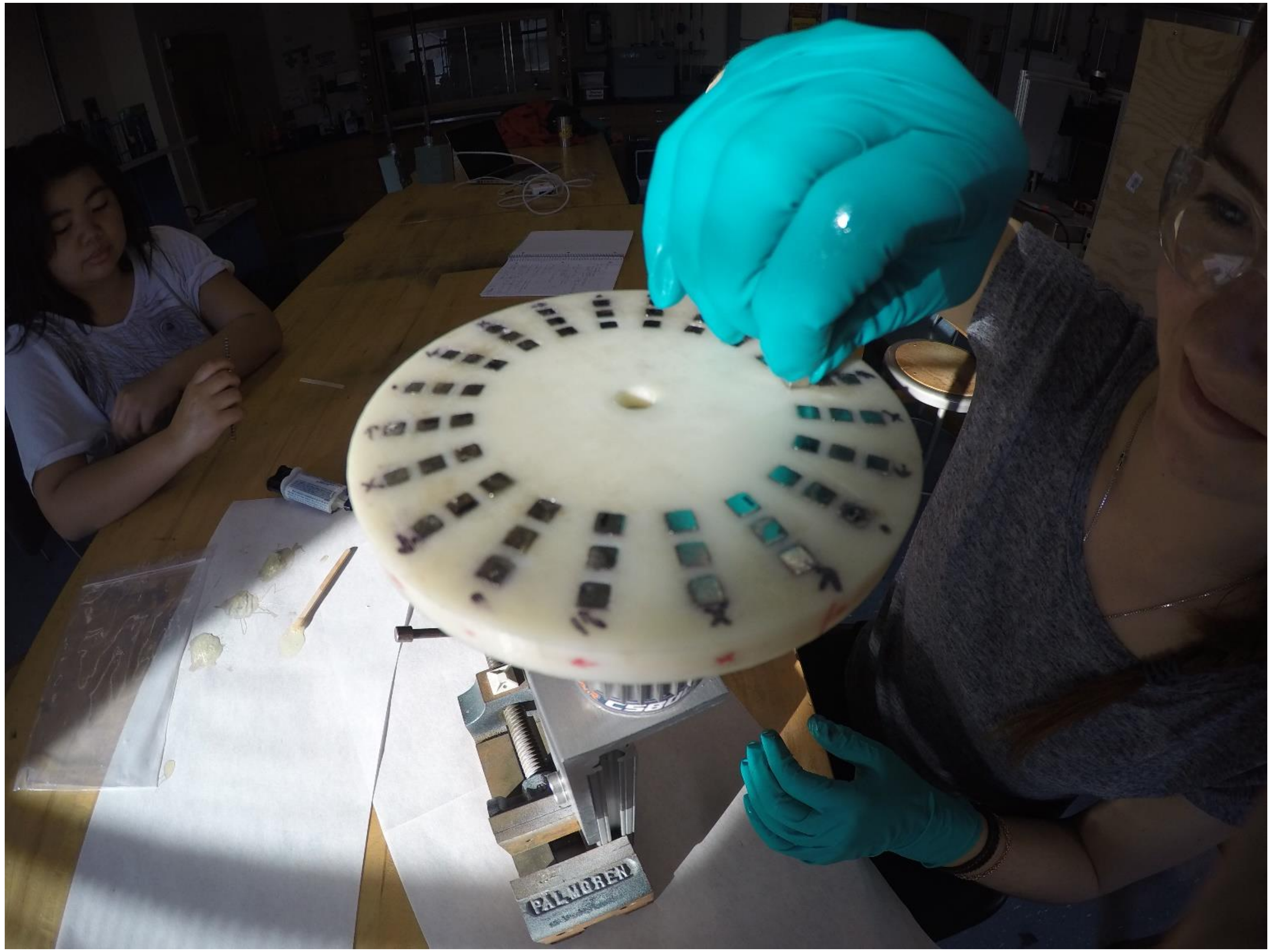
- System utilizes four Arx Pax Magnetic Field Architecture (MFA) hover engines
- Electronically adjustable hover height
  - Aiming for 0.20” (5mm) pending further testing
- Four engine payload
  - 550 lbs

# MAGNETIC LEVITATION

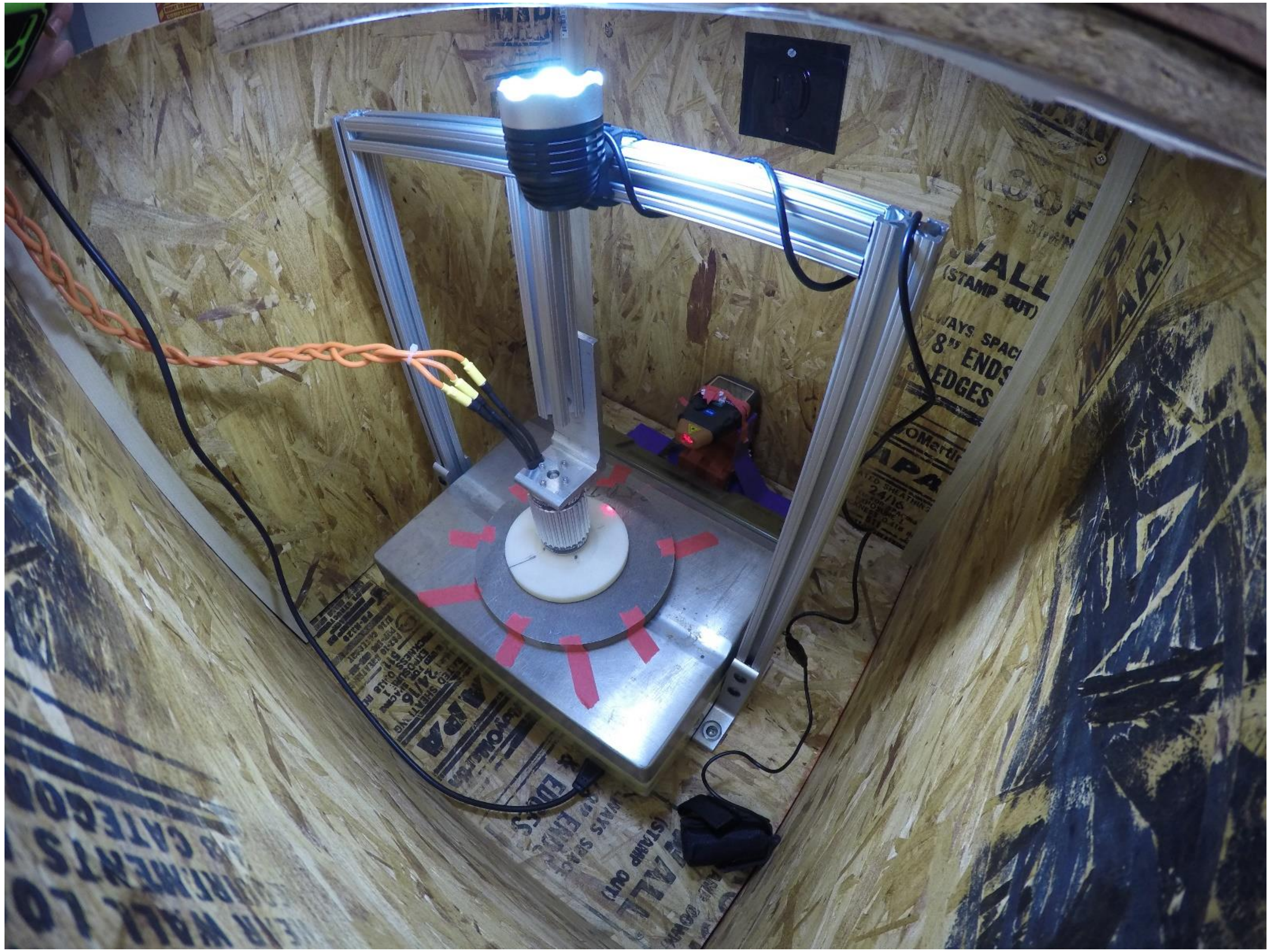
- Best chance of success for competition while still adhering to the future scalability of the Hyperloop
  - Operate at high speeds and in low-pressure environments
  - Levitation + Propulsion + Braking + Control

Arx Pax HE3.0 Hover Engine

# MAGLEV PROTOTYPING



# MAGLEV PROTOTYPING

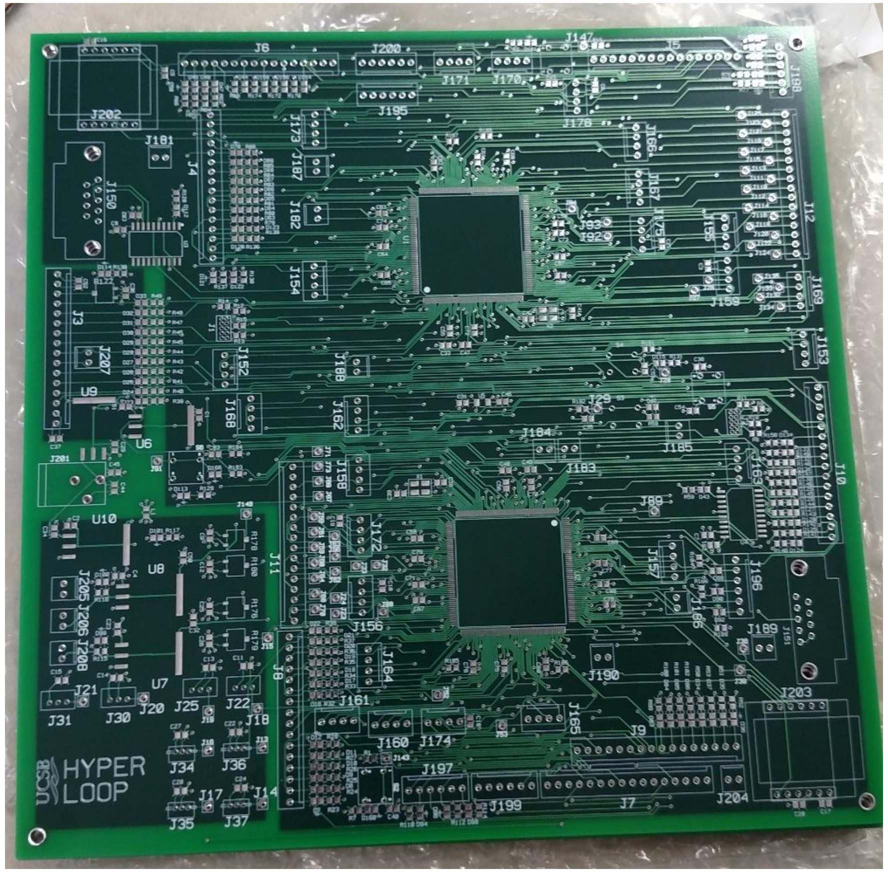


# MAGLEV PROTOTYPING

# SYSTEM CIRCUIT BOARD

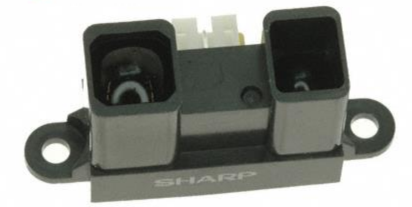
- 8.1” x 8.1” printed circuit board
  - (2) LPC NXP4088 microcontrollers
  - Actuation
  - Sensor interface
  - Communication
  - Pod-stop command
  - Control systems

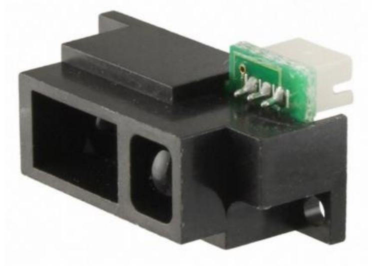
- Already fabricated and awaiting assembly

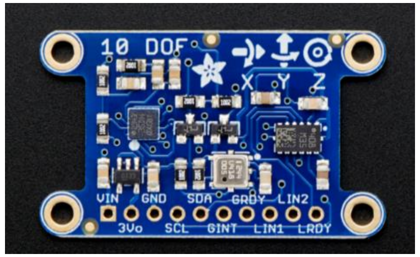


# SENSORS

- **Photoelectric sensor***:*
  - Detects reflective strips on top half of tube
- **Short-range ranging sensor***:*
  - Determines height relative to bottom of tube
- **Long-range ranging sensor**:
  - Gives position relative to sides of the tube
- **Consolidated Board**:
  - Accelerometer
  - Gyroscope
  - Barometer
  - Thermometer





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Braking
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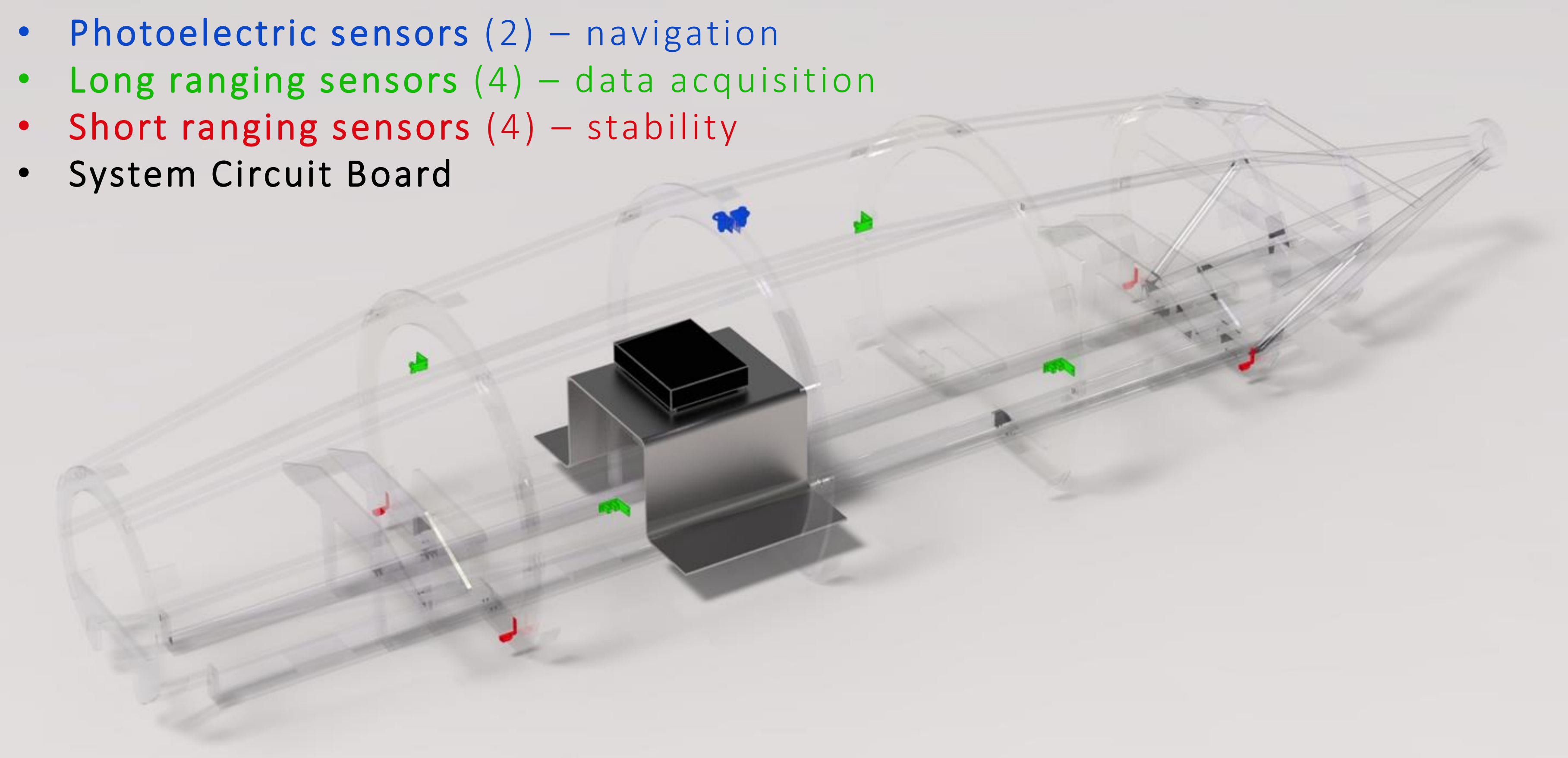
# SENSOR LOCATIONS

- Photoelectric sensors (2) – navigation
- Long ranging sensors (4) – data acquisition
- Short ranging sensors (4) – stability
- System Circuit Board

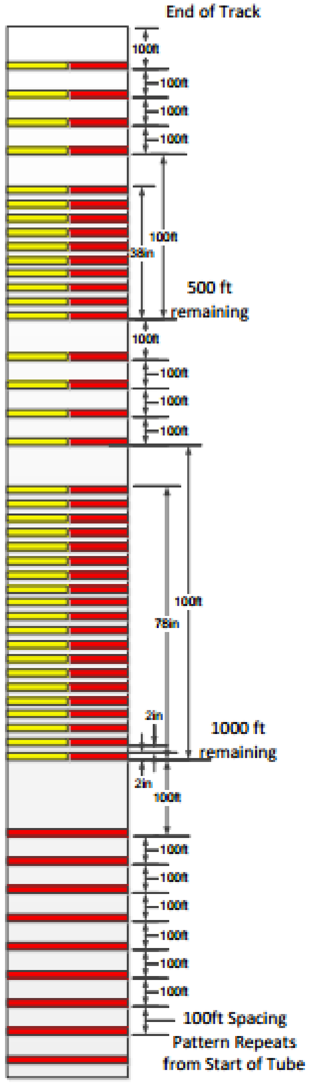


# PROTOTYPING

- Currently prototyping sensors on LPC NXP4088 Developer’s Kit
- Testing cabling constraints on a full-sized model

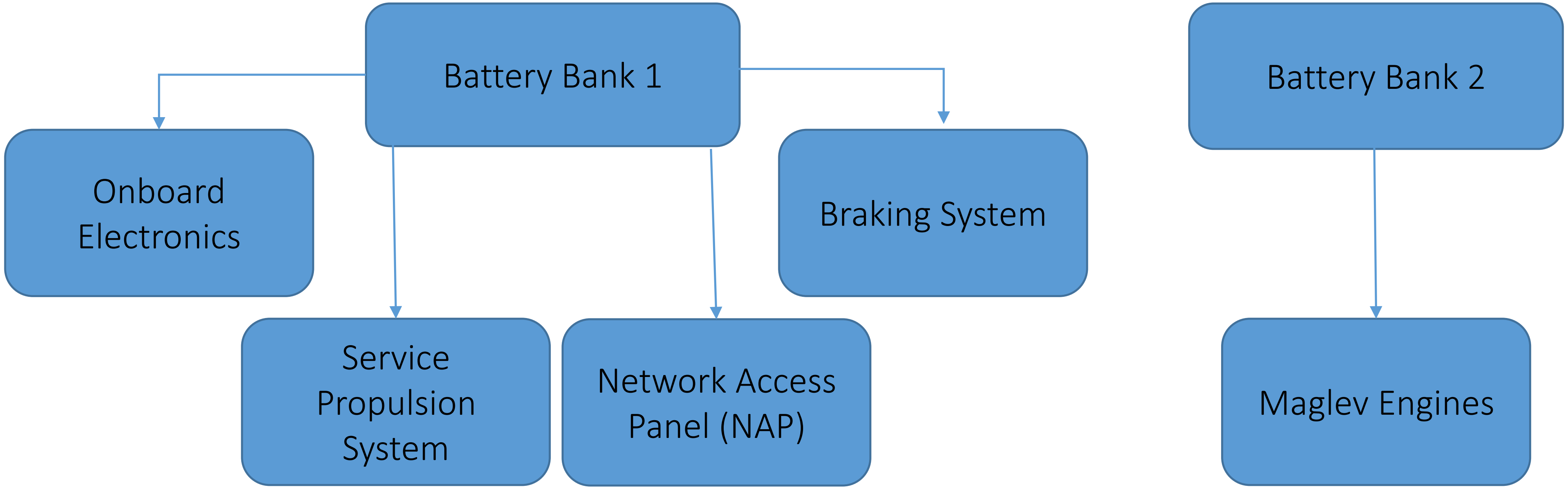
# CONTROL SYSTEMS

- Navigation
  - Absolute position with photoelectric sensor
  - Double integrate accelerometer between strips
- Stability
  - Absolute position with short range ranging sensors
  - Relative position with gyroscopes
  - Adjust each engine’s levitation to maintain stability and correct disturbances
- Braking
  - Microcontroller activates/disengages brake system solenoid
  - Automatically applied if connection lost for >5 secs

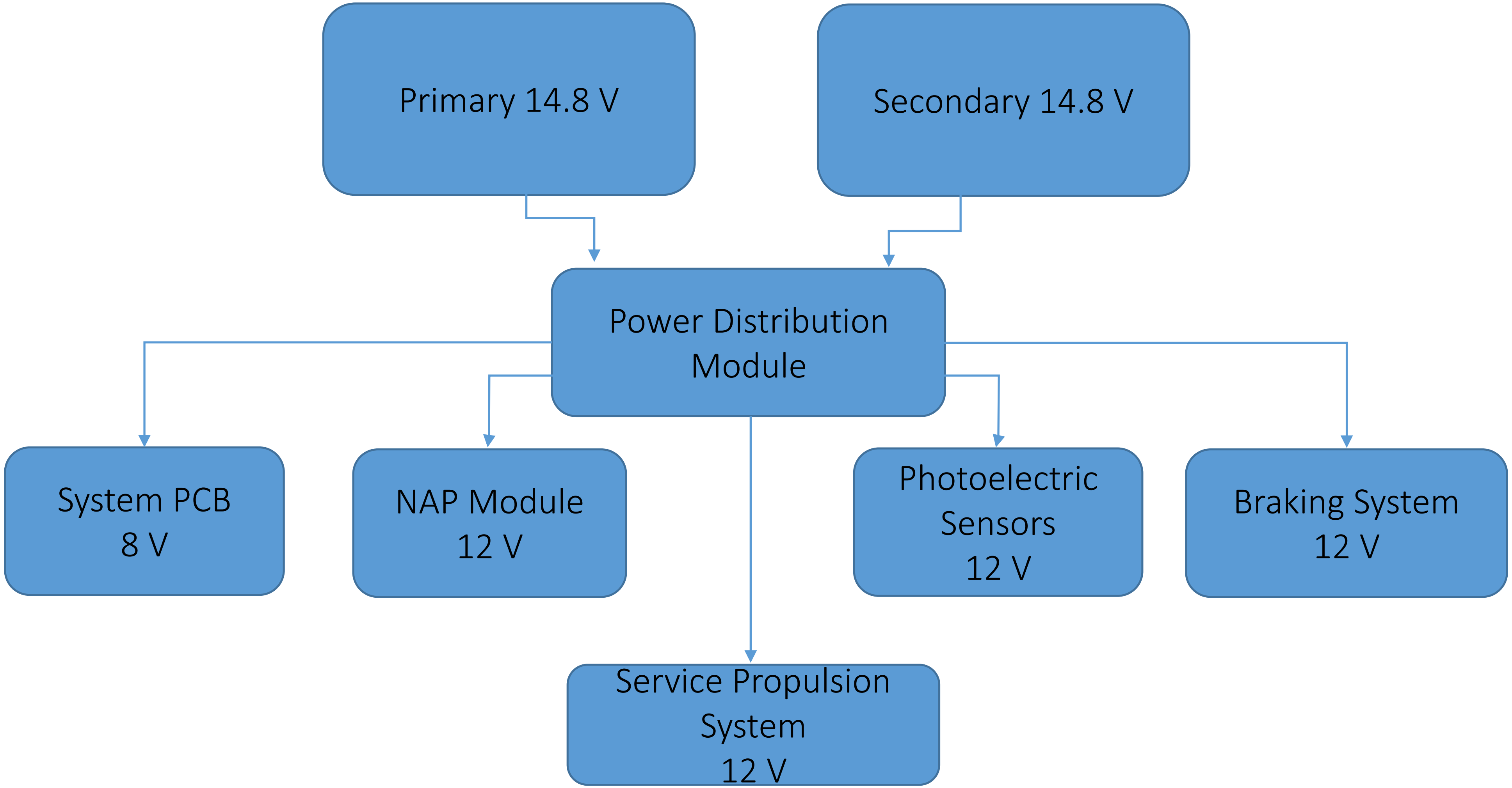


# POWER SYSTEM

- **Battery Bank 1**
  - Onboard electronics, NAP, braking, service propulsion
- **Battery Bank 2**
  - Magnetic levitation system

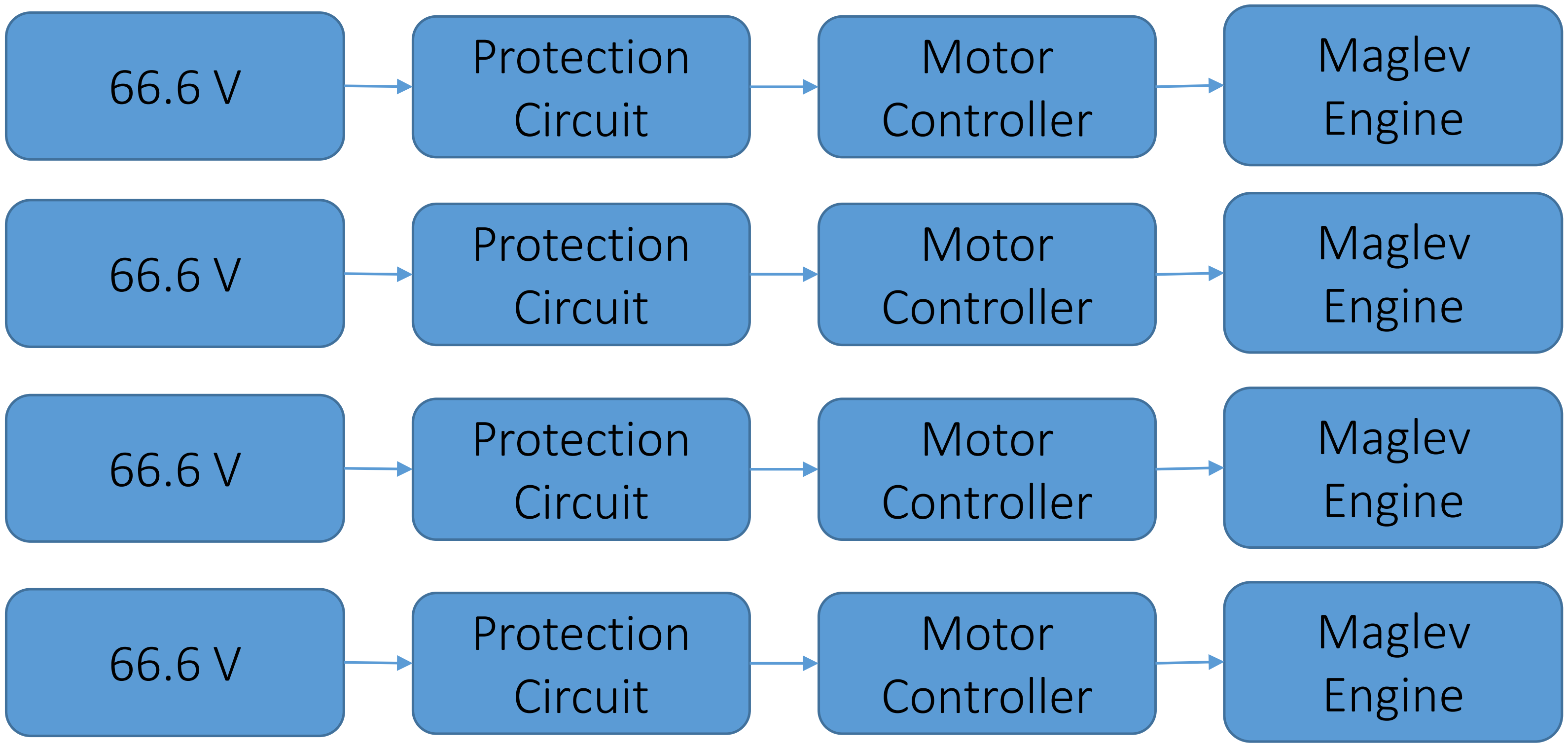


# BATTERY BANK 1



# BATTERY BANK 2

- Independent power supply for each engine
  - 20Ahr capacity (per engine) for 26.2 min of levitation
- Protection circuit to prevent battery over-discharge
- Motor controller communicates with System PCB

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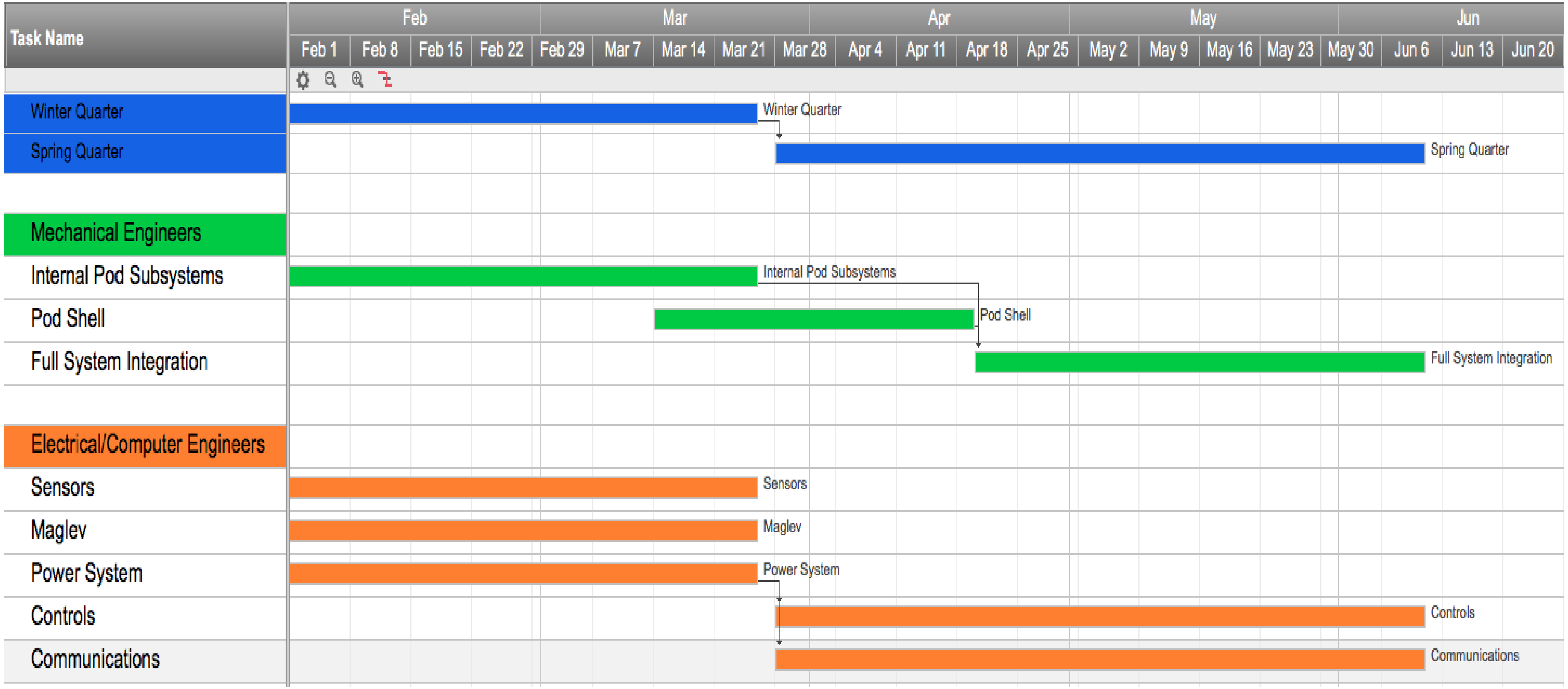
# BATTERY SELECTION

- Lithium polymer (LiPo)
  - Battery of choice for quadcopter/drone applications
    - Optimal capacity/weight ratio
    - High discharge rating
    - Easily obtainable off-shelf packs
  - Fire safety
    - Fire resistance bags encase each battery bank
    - Stainless steel LiPo charge box to prevent battery puncture in the event of a crash



# PRODUCTION SCHEDULE



# CONCLUSION

- Work began in October 2015
  - With school schedules—effectively 12 weeks of work

- Accomplishments
  - **Raised $15,000—need $25,000 to reach goal of $40,000**
  - Printed Circuit Board is in assembly
    - Prototyping sensors with NXP Developer's Kit
  - 3D printed model
    - Used for extensive wind tunnel testing
  - Magnetic levitation testing & prototyping
  - Styrofoam and PVC pipe model of frame completed
    - Beginning to work with cabling
  - Established a finance/marketing team

# CONCLUSION

- Thank you to our mentors and our sponsors.
- Please find us at Booth 64 or contact us:
  - ucsbhyperloop@gmail.com
  - ucsbhyperloop.com
  - @UCSBHyperloop

Raytheon

IR Ingersoll Rand